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Determination of the Voids in the Mineral Aggregate

1. SCOPE

1.1 Voids in the mineral aggregate (VMA) is the void spaces between the aggregate particles of the compacted mix. This void space includes the air voids and the effective asphalt content, which is the total asphalt content minus the quantity of asphalt lost by absorption into the aggregate particles.

1.2 VMA in this procedure is calculated in accordance with the Asphalt Institute's "Mix Design Methods for Asphalt Concrete (MS-2)" manual.

2. CALCULATION

2.1 VMA is computed as follows:

$$VMA = 100 - \frac{G_{mb}}{G_{sb}} \times \frac{100}{100 + P_b} 100$$

Where:

VMA = percent voids in the mineral aggregate, to the nearest 0.1%.
G_{sb} = bulk specific gravity of the aggregate blend, to the nearest 0.001.
G_{mb} = bulk specific gravity of compacted mixture (CT 308, Method A), to the nearest 0.001.
P_b = asphalt binder content, percent by mass of aggregate, to the nearest 0.1%.

2.2 The bulk specific gravity of the aggregate blend, G_{sb}, is computed using individual specific gravities of coarse aggregate, fine aggregate and, if used, mineral filler and RAP. Individual bulk specific gravities of aggregate, determined on the oven-dry basis, is used for computations when the aggregate is dry or assumed to be dry as, for example, when used in asphalt concrete.

2.2.1 The bulk specific gravity (oven dry basis) of coarse aggregate is determined in accordance with CT 206.

2.2.2 The bulk specific gravity (oven dry basis) of fine aggregate is determined as follows:

Calculate the bulk specific gravity, determined on a saturated surface dry (SSD) basis, and the absorption of fine aggregate in accordance with CT 207. Compute the bulk specific gravity of fine aggregate (oven dry-basis) as follows:

$$G_d = \frac{G_s}{1 + \frac{A}{100}}$$

Where:

G_d = bulk specific gravity (oven dry-basis), to the nearest 0.001
G_s = bulk specific gravity [saturated surface-dry basis (SSD)] (CT 207), to the nearest 0.001
A = absorption, in percent (CT 207), to the nearest 0.1%

2.2.3 The bulk specific gravity of the mineral filler is difficult to determine accurately. However, if the apparent specific gravity of the filler is substituted, the error is usually negligible. The apparent specific gravity of mineral filler is determined in accordance with CT 208. Report results to the nearest 0.001.

Note 1 – When hydrated lime is used in the mix, the lime shall be considered as part of the aggregate blend. The specific gravity for the lime shall be 2.380 for the purpose of the calculation in Section 2.3.

2.2.4 When the total mix contains 15 percent or less of recycled asphalt pavement (RAP), the bulk specific gravity of the aggregate contained in the RAP shall be assumed to be the same as the effective specific gravity of the aggregate contained in the RAP for the purpose of the calculation in Section 2.3. The effective specific gravity of the aggregate is computed as follows:

$$G_{se} = \frac{100}{\frac{100 + P_{br}}{G_{mmr}} - \frac{P_{br}}{G_{br}}}$$

Where:

G_{se} = effective specific gravity of aggregate (in RAP), to nearest 0.001.
G_{mmr} = maximum specific gravity of RAP mixture (CT 309), to nearest 0.001
P_{br} = asphalt binder content of RAP, percent by mass of aggregate, to nearest 0.1%
G_{br} = specific gravity of asphalt binder in RAP (see Note on Figure 1 in CT 367), to nearest 0.01.

2.3 The bulk specific gravity of the aggregate blend is computed as follows:

$$G_{sb} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}}$$

Where:

P_1, P_2, P_n = individual percentages by mass of aggregate, to the nearest 0.1%
G_1, G_2, G_n = individual bulk specific gravities (oven-dry basis) of aggregate, to the nearest 0.001

3. EXAMPLE

Given:

Constituent or Paving Mixture	Specific Gravity	Composition – Percent by Mass of Total Aggregate
Asphalt Binder	1.02 (G_b)	5.6 (P_b)
Coarse Aggregate	2.720 (G_1) – Oven Dry Basis	35.0% (P_1)
Fine Aggregate [1]	2.700 (G_s) – SSD	48.5% (P_2)
Mineral Filler (Lime)	2.380 (G_3)	1.5% (P_3)
RAP [2 and 3]		15.0% (P_4)
Bulk Specific Gravity of Compacted Mixture	2.440 (G_{mb})	
Maximum Specific Gravity of RAP	2.535 (G_{mmr})	

[1] Fine Aggregate Absorption = 0.4%
[2] Asphalt Binder Content of RAP = 6.5% (P_{br})
[3] Specific Gravity of Asphalt Binder in RAP = 1.02 (G_{br})

Calculate:

G_d for fine aggregate (will be G_2 in the calculation for G_{sb} below):

$$G_d = \frac{G_s}{1 + \frac{A}{100}} = \frac{2.700}{1 + \frac{0.4}{100}} = 2.689$$

G_{se} of RAP:

$$G_{se} = \frac{100}{\frac{100 + P_{br}}{G_{mmr}} - \frac{P_{br}}{G_{br}}} = \frac{100}{\frac{100 + 6.5}{2.535} - \frac{6.5}{1.02}} = 2.806$$

G_{sb}:

$$G_{sb} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}} = \frac{35.0 + 48.5 + 1.5 + 15.0}{\frac{35.0}{2.720} + \frac{48.5}{2.689} + \frac{1.5}{2.380} + \frac{15.0}{2.806}} = 2.711$$

VMA:

$$VMA = 100 - \frac{G_{mb}}{G_{sb}} \times \frac{100}{100 + P_b} 100 = 100 - \frac{2.440}{2.711} \times \frac{100}{100 + 5.6} 100 = \underline{\underline{14.8}}$$